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16.

DIFFERENTIAL DIAGNOSIS OF THE APPENDIX BY AID OF THE ROENTGEN RAY.

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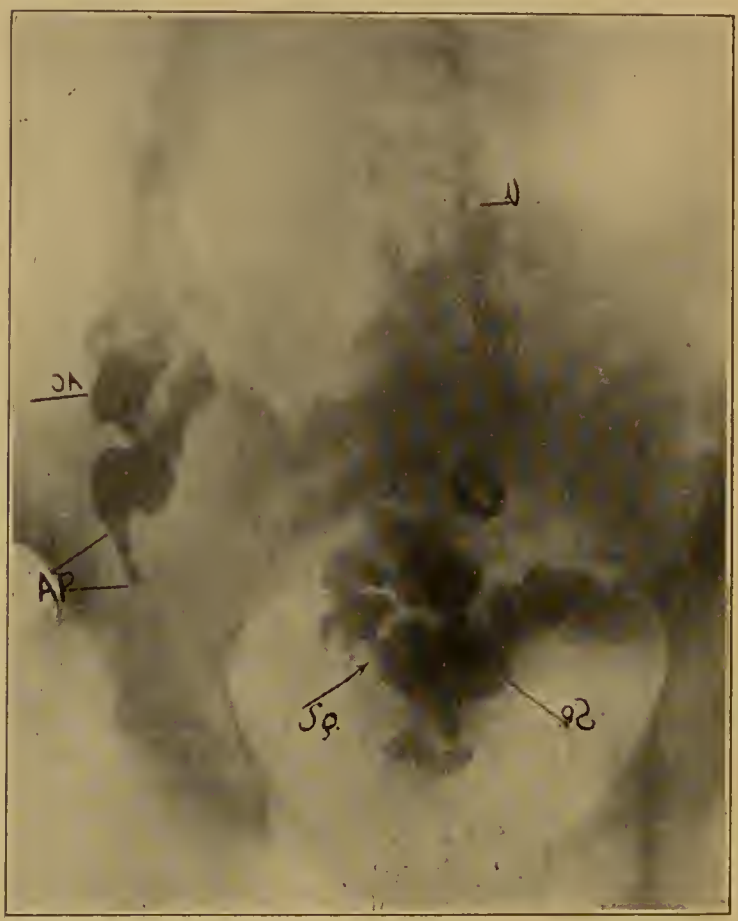
The x ray study of the appendix has never had until now a scientific basis sufficiently strong and broad to warrant the assertion that such routine procedure is a necessary aid in separating appendicitis from the various pathological phenomena which occur in the right lower abdomen. Only occasional references have been made by several writers to the shadows formed by the appendix in radiographs.

The early experimenters in radiography of the appendix frequently met with failure because improper technic was employed. But after prolonged study of many cases and numerous examinations both fluoroscopically and radiographically, I have been able to indicate by examination of the cecum and the adjacent structures whatever condition may exist with accuracy.

In the examination of 141 cases between May 1, 1913, and September 15, 1913, data were obtained which enabled me to classify the appendix radiographically. Of this number, fifty patients had had laparotomies previous to the examination in which the appendix had been removed. Of the remainder, ninety per cent. gave sufficient data to determine the position and condition of the appendix. The remaining ten per cent. were those in whom the position of the cecum prohibited its thorough inspection.

The following classification covers the essential points in the findings of the average case, so that conclusions may be drawn that will permit a diagnosis to be made:

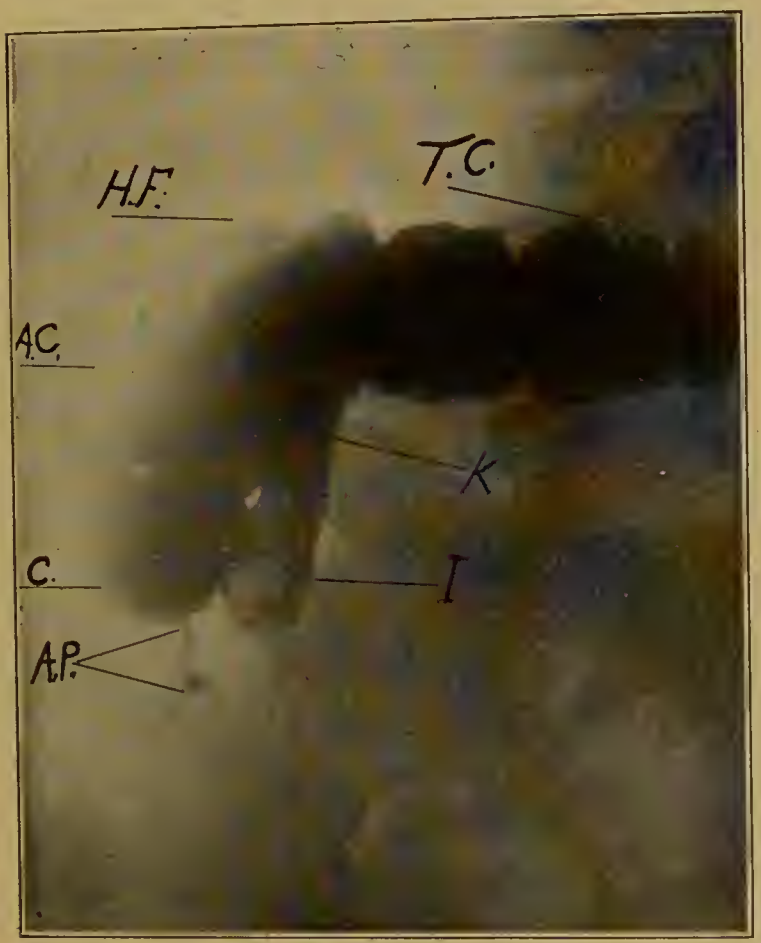


RADIOGRAPH 1.—Mrs. W. Referred by Dr. E. L. Kellogg. *Ap.* Appendix; *A.C.* ascending colon; *U.* umbilicus; *Sg.* sigmoid. In the radiograph this appendix is apparently straight but in reality under normal conditions is kinked. Its tip is adherent to the outer abdominal wall. Upward retraction on the cecum at the time the radiograph was taken has straightened the appendix out. The constriction observed near its tip is the point of angulation when the cecum drops. This radiograph also illustrates cecal stasis due to Jackson's membrane.

1. Functionating or nonfunctionating. 2. Fixed or movable. 3. Ascending, descending, or trans-

verse. 4. Straight, kinked, curved, looped, or clubbed.

A functionating appendix is capable of receiving and discharging feces. In the human being it must



RADIOGRAPH 2.—Miss M. Referred by Dr. E. L. Kellogg. *Ap.* Appendix; *C.* cecum; *A.C.* ascending colon; *T.C.* transverse colon; *I.* ileum; *H.F.* hepatic flexure. The appendix is functionating, fixed, and of the descending curved type. It is adherent to the outer abdominal wall throughout its entire length. The cecum and ascending colon are also tightly bound with a Jackson's membrane.

be regarded as a part of the intestines and is therefore subject to the same laws. Accepting the fact of its power to receive and discharge material and

using this as a basis for an analysis of its condition, we can then turn to the known laws with regard to the motility of the colon. The colon has been found to respond to a natural mechanical stimulus which starts a peristaltic wave at intervals of about four hours each. In examining the patient for stasis I have observed when the patient ingests a quantity of food or liquid the results are a decided forward movement of the bowel contents.

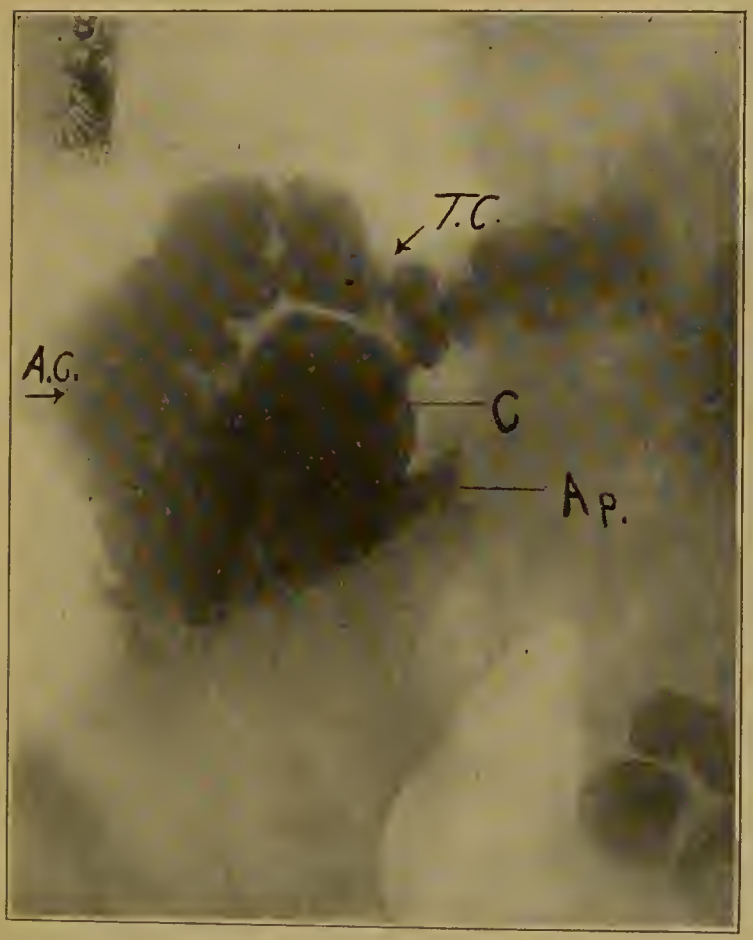
Accepting these facts of the normal four hour period, modified by ingesting food, etc., we may expect the appendix to discharge its contents under similar condition. Colonic peristalsis is inhibited at any point where a pathological abnormality occurs. As a rule, if there is any adhesion or constriction of the colon the peristaltic wave starts beyond this point at approximately normal periods. The repeated attempts of the bowel to carry its contents past an obstruction usually results in dilatation and eventually loss of compensation, with disturbance of peristaltic function and if, as physiologists believe, the normal wave of peristalsis originates in the appendix then we may expect a disturbance of function to occur in it whenever obstructive phenomena of material degree are manifested.

A nonfunctionating appendix may be incapable of receiving material because of the obliteration of its canal. It may receive feces and only discharge part, retaining the residue for indefinite periods. The writer has observed retained bismuth[1] a number of weeks following an examination. In one case referred by Dr. S. L. Cash, and recently examined, the bismuth was found in the appendix when the latter was removed at operation.

The nonfunctionating appendix is always patho-

[1]The opaque salts used in this work are bismuth subcarbonate and barium sulphate. If administered in sufficient doses bismuth subnitrate may be poisonous. This is due to chemical decomposition resulting in nitrite poisoning. If not properly washed barium sulphate may contain barium chloride, a soluble poisonous salt. Conservatively we may estimate that in x ray examinations 60,000 patients have received bismuth and barium salts with no ill effects, except where bismuth subnitrate or impure barium sulphate was employed.

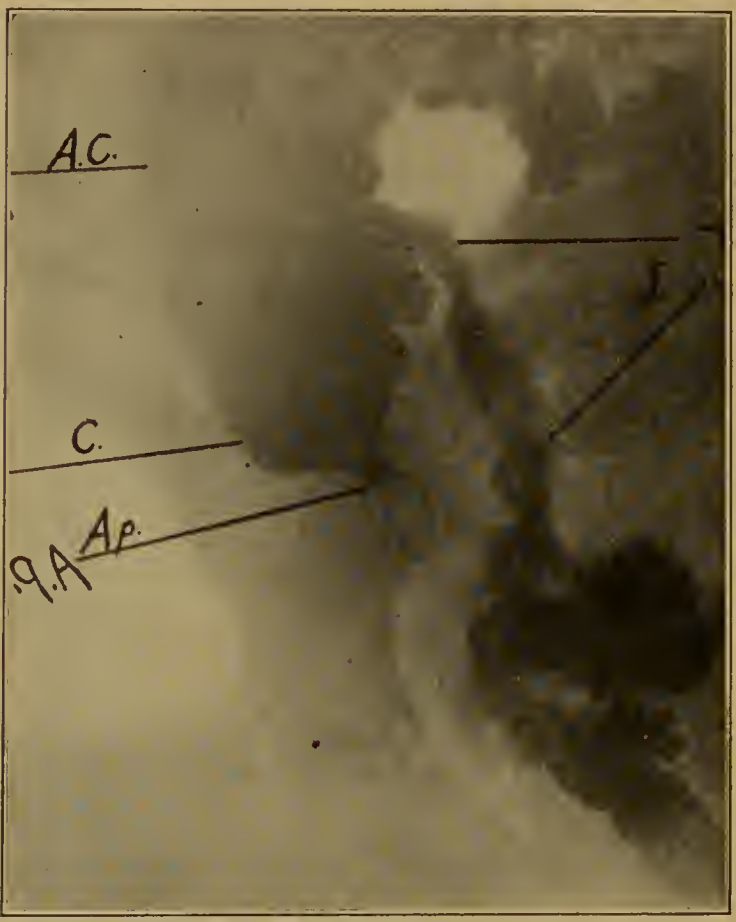
logical, either having changes within its walls or dense adhesions surrounding it. Chronic inflammatory processes always end in replacing the normal structures with fibrous connective tissue. In the appendix such a process involving the muscular



RADIOGRAPH 3.—Mrs. S. Referred by Dr. Mefford Runyon. *Ap.* Appendix; *C.* cecum; *A.C.* ascending colon; *T.C.* transverse colon. This is a large mobile cecum which was retracted upward while the radiograph was being taken. This exposes a short kinked appendix so doubled on itself, as to cause the two sections to appear as one.

coat ends in loss of peristaltic motility; moreover, should connective tissue form in the other layers of its structure, or adhesions extending from adjacent

parts bind it down, we have a degeneration of the muscle fibre caused by direct mechanical interference, disturbance of nutrition and reflex control, thereby causing diminished peristalsis. When this occurs feces with or without the normal food con-



RADIOGRAPH 4.—Mrs. McI. Referred by Dr. W. B. Graves. *Ap.* Appendix; *C.* cecum; *A.C.* ascending colon; *I.* ileum. This is a chronic appendix, nonfunctionating, of the kinked type, and adherent to the cecum.

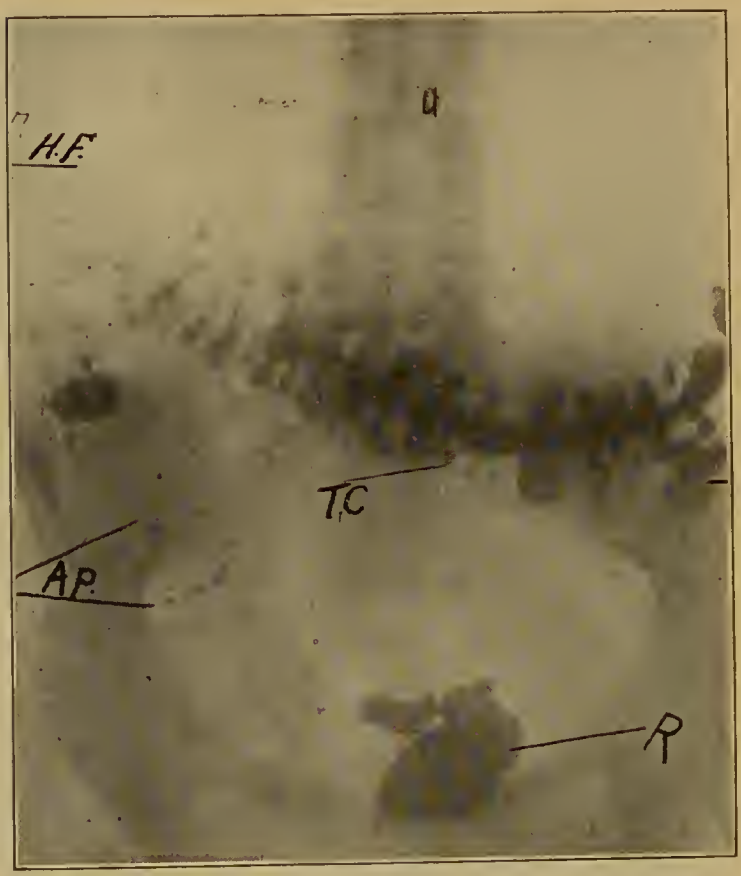
stituents may enter the appendix and be retained indefinitely.

The fixed appendix is usually adherent to the abdominal wall. Otherwise it is attached to the ad-

jacent viscera that are held by adhesions which prevent displacement by manipulation. A type of fixed appendix is illustrated in the accompanying radiograph. Palpation or pressure while examining under the fluoroscope enables one to readily deter-

RADIOGRAPH 5.—Mr. W. Referred by Dr. W. S. Bainbridge. *Ap.* Appendix; *C.* cecum; *I.* ileum; *A.C.* ascending colon; *Sg.* sigmoid; *T.C.* transverse colon; *U.* umbilicus; *S.* stomach; *D.C.* descending colon; *R.* rectum; *Cn.* constriction. In this case the appendix is adherent to the terminal ileum, is curved, transverse, and functionating. The favorable position permits it to readily drain in spite of the fact that it is adherent. Attention is called to the constriction on the ascending colon due to a mesenteric band which is, no doubt, the point of resistance in what appears to be a normal colon.

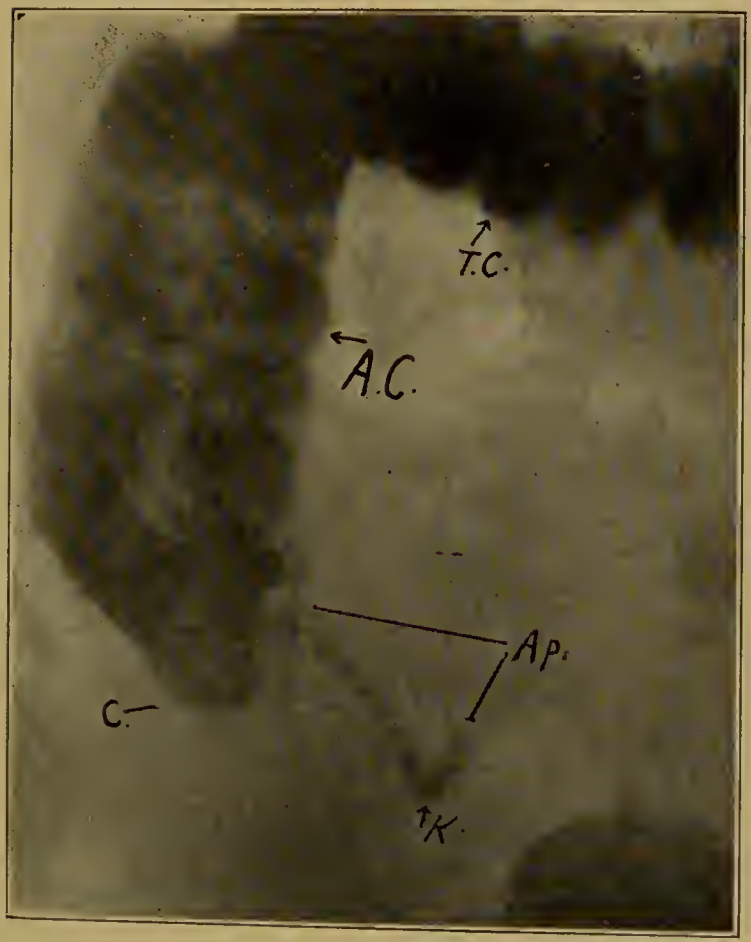
mine the degree of fixation. A portion of the appendix may be fixed, especially the tip or end, as quite a number of the cases examined have an adherent tip and free shaft; this results in a movable appendix in which mobility may be deceptive when



RADIOGRAPH 6.—Mrs. G. Referred by Dr. H. D. Meeker. *Ap.* Appendix; *T.C.* transverse colon. This is a curved nonfunctionating appendix the tip of which is adherent to the inner side of the cecum, while the shaft was firmly fixed to the ileum. This appendix under manipulation through the abdominal wall could only be displaced a very short distance, while its curved even contour could not be changed whatsoever. Careful inspection of the radiograph will show that the tip of the appendix turns downward where attached to the cecum, literally producing a kink. The sausage like sections of bismuth can be readily perceived.

the tip of the appendix does not contain the opaque salts.

A movable appendix may be so definitely changed in position as to delay its return to the original position or may be fixed at one segment, for instance the tip, and the remainder be readily displaced by



RADIOGRAPH 7.—Mr. T. Referred by Dr. Earnest Bishop. *Ap.* Appendix; *K.* kink in the appendix; *C.* cecum; *A.C.* ascending colon; *T.C.* transverse colon. The tip of this appendix is attached to the sigmoid in such a position that, when the patient is horizontal, the cecum drifts upward and produces a kink at the juncture of the shaft with the adherent tip. This appendix was large, very easily palpated, and was nonfunctionating, retaining its bismuth several days.

shifting the cecum or, if of unusual length, the shaft will be readily carried to another position; if ad-

herent to a movable structure its position can be changed by manipulation, in which instance a differentiation can be made if the attached viscera contains an opaque material. The general direction of

RADIOGRAPH 8.—Mr. DeL. Referred by Dr. William Hayes. *Ap.* Appendix; *I.* ileum; *C.* cecum; *A.C.* ascending colon. This appendix was very large, easily palpated, nonfunctionating, and of the ascending type. With the patient erect it acted as a supporting ligament for the cecum. Its tip was adherent well up into the abdomen. The patient had been subjected to several years' medication for ulcer. His principal symptom was a persistent dragging pain near the median line close to the umbilicus.

a movable appendix can be so changed as to reverse it from the ascending to the descending type.

As a rule the ascending type is adherent; the tip may extend to the transverse colon or liver. They usually point upward and inward to the right of the umbilicus and as a rule lie between the median line and the ascending colon. Several have been observed to lie anterior, others posterior or to the outer side of the ascending colon. The general complaint of these patients has been of discomfort when walking or being carried in a jolting vehicle. In the horizontal position the appendix is relaxed and looped or sometimes doubled on itself; this depends upon the degree to which the cecum recedes upward. The tip alone may be adherent or the entire shaft involved in a mass of adhesions. When these patients are in the erect position the cecum drops, traction occurs, and the appendix is extended to its full length. Difficulty is usually experienced in radiographing the patient standing, because the dropping down and inward rotation of the cecum and ascending colon causes the appendix to be overshadowed. Any attempt to displace these structures by manipulation is difficult because of the muscle tension of the abdomen and the massing together of the abdominal contents.

The descending appendices are generally found to be normal. If adherent or deformed in any way they are more easily manipulated and radiographed because of their freedom from the influence of the larger cecum and ascending colon, and the fact that the ileum posteriorly forms a firm background and decreases the anterior posterior depth of the abdominal cavity. Many of this type are found adherent at the tip, accompanied by a somewhat immobile cecum which does not descend very far; this latter condition may be accounted for in several ways, but the most rational explanation is that when the cecum is retained in a high position there is better drainage. The more abnormalities found in connection with the inspection of the cecum, the ascending colon, and transverse colon, the greater the proportion of abnormal appendices. This is al-

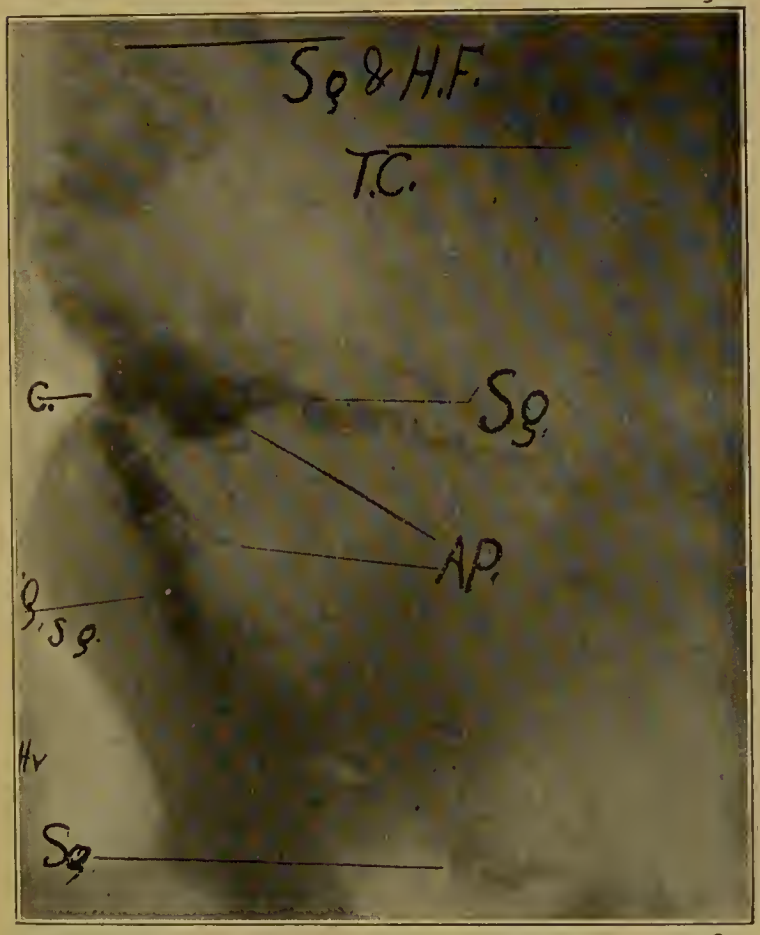
most an invariable rule. Adhesions, mesenteric bands, and angulations involving the colon, resulting in stasis in the cecum and ascending colon, nearly

RADIOGRAPH 9.—Mr. S. Referred by Dr. H. Austin Cossitt. *Ap.* Appendix; *C.* cecum; *A.C.* ascending colon; *Cn.* constriction; *I.* ileum. This appendix is adherent. It will be observed that there is a very small amount of bismuth distributed throughout the appendix. This is no doubt due to the appendix having been filled with feces previous to the administration of the bismuth. The day following this examination the entire appendix was very opaque. This illustrates how one superficial examination may cause us to overlook an appendix with a small quantity of bismuth within it, especially if well diluted with other material.

always accompany the abnormal appendices and are found if the examination is complete. (Attention is

called to several of the radiographs illustrating this point.)

The transverse type usually points directly inward

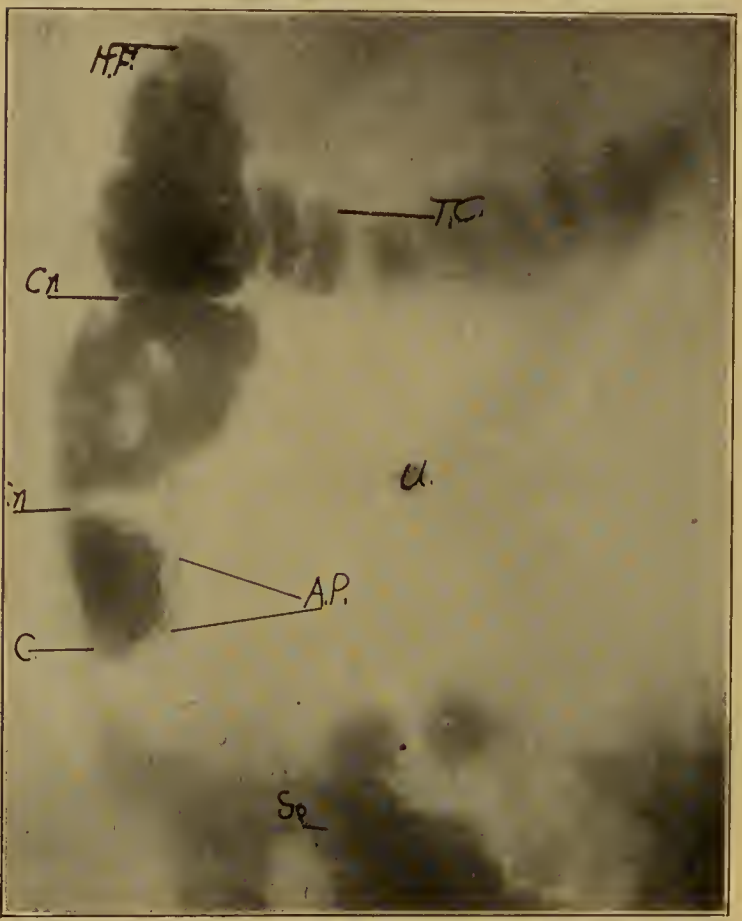


RADIOGRAPH 10.—Mr. A. Referred by Dr. Henry Eichorn. *Ap.* Appendix; *Sg.* sigmoid; *T.C.* transverse colon; *C.* cecum. This very long irregular appendix adherent at the tip, is nonfunctionating, and of the movable descending type. The tip is adherent to the sigmoid. The sigmoid is unusually long. It passes upward to the right of the cecum to a point near the hepatic flexure, where it is adherent, then drops down and swings across the abdomen below the transverse colon to the splenic flexure. This unusual case will be reported in another group.

to the median line. Downward displacement of the cecum may carry it into such position that objec-

tively it may seem to be of the ascending type and especially so if the distal end is adherent.

In this classification I am attempting to place each group with due regard to the classical McBurney's



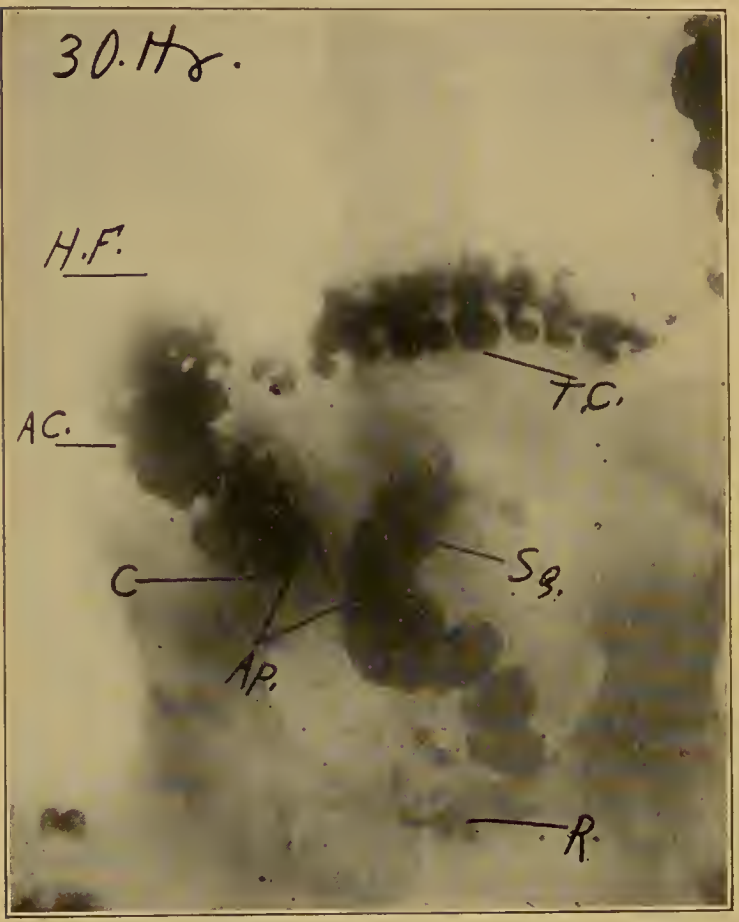
RADIOGRAPH 11.—Dr. D. Referred by Dr. William Hayes. *Ap.* Appendix; *C.* cecum; *Cn.* constriction; *U.* umbilicus. This appendix is of the ascending type, is adherent to the cecum and ileum, resting on the inner wall of the cecum to which it was firmly bound.

point, using this landmark as a centre of radiation and considering the appendix only as observed when the patient is lying horizontal, or in the position in which laparotomies are performed.

The fourth class can be broadly divided into four groups. The shape as observed with the x ray va-

RADIOGRAPH 12.—Mrs. K. Referred by Dr. Austin Cossitt. *Ap.* Appendix; *C.* cecum; *A.C.* ascending colon; *Sg.* sigmoid; *T.C.* transverse colon. In this case several examinations were made and the position of the appendix determined, but the retention of the bismuth in the cecum and ascending colon prevented radiographing the appendix, as it was attached to the ascending colon in such a way as to fall in line with it. Following the administration of an enema containing the opaque salt the cecum and ascending colon was partially cleared of their contents, when peristalsis carried the enema into the transverse colon. It will be observed that the peristaltic wave has almost reached the splenic flexure. This permitted the appendix to come in view. As outlined it can be seen passing upward on the inner side of the cecum and onto the anterior wall of the ascending colon. This appendix is a nonfunctionating, ascending, movable, and club shaped type.

ries greatly. The radiograph is but a shadow of superimposed parallel planes and false conceptions of the shape and contour may be obtained if thorough familiarity with the relative values of the dif-



RADIOGRAPH 13.—Mr. A. Referred by Dr. Charles Anthony. *Ap.* Appendix; *C.* cecum; *Sg.* sigmoid. This appendix is adherent at the tip and is of the descending straight type. At operation the tip was found to be bulbous and adherent. The bulbous tip was not exhibited in any of the radiographs; evidently the cavity of the tip was small.

fusion of the shadow cast by the various segments is not taken into consideration; the nearer the radiographed object is to the plate and the farther it is

from the target of the x ray tube, the sharper the image, while that portion of the plate is proportionally diffused and rendered dull in contour. Stereoscopic studies of a long distorted appendix may be of material aid in determining its exact relations to the surrounding structures.

An appendix which is objectively straight when observed under the fluoroscope or by the radiograph may be kinked or partially obliterated and, unless it contains bismuth or an opaque salt throughout its length or may be moved by manipulation so as to bring the kink or curve to a right angled plane with the x rays, may be regarded as one without abnormalities.

A curved appendix, if the entire length can be observed, when found to be of uniform contour and functionating, may be considered as normal, although we must keep in mind the probability of its shape being influenced by the drop of the cecum when the patient is erect; this point impresses the fact on our mind that the ptosed and mobile cecum may throw an appendix into an unfavorable position or distort it and produce an acute angulation which would interfere with function.

The kinked appendix is usually pathological and appears as a short stump curling backward toward the cecum. Another type of the kinked appendix is that in which the tip is adherent in such a position that it may rest with its long axis at an angle with the common position of the shaft. If this occurs a shifting of the viscera may decrease the degree of angle or straighten the kink. (A type is illustrated.)

In the club shaped appendix the greater diameter of its cavity at the tip presents the appearance of a small ball of the opaque salts at the end of the shaft.

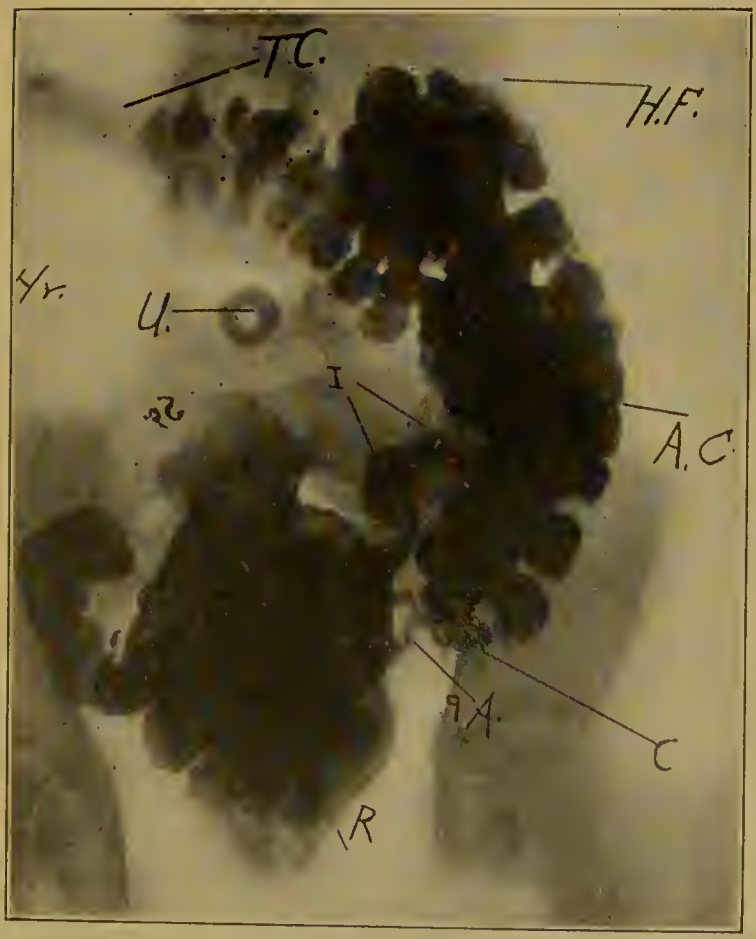
The looped appendix may be of considerable length. Several have been found with two or three loops and apparently six to ten inches in length, although the exact measurement is difficult to determine because of its numerous curves. These appen-

dices are not necessarily diseased and their exact position is oftentimes difficult to determine. The length of time they retain the bismuth, the mobility, the diameter, and the degree of tenderness are determining factors in diagnosticating their acute condition.

In all x ray examinations due allowance must be given for modifying factors such as the thickness of the abdominal wall, sensitiveness of the patient to palpation and manipulation, gaseous distention, scars, tumors, etc. One who is familiar with the physical examination of the abdomen knows well the influence that these conditions have on the manipulation of the viscera. The x ray enables us to locate the appendix and then, if permissible, aids in moving it about or placing the hand on it in such a way as to palpate its various segments. The size of the appendix naturally places restriction on the degree to which we can perceive its outline by the sense of touch. The well known skill of several able surgeons who have amply demonstrated the feasibility of palpating this structure has clearly proved that this is possible under favorable conditions without the aid of the x ray. However, by its use we can promptly locate the appendix and be certain that the organ which our fingers outline is none other than what we desire to find. I have been very much impressed with the deceptive character of bands of the abdominal facia, or bands of adhesions, and thickened intestinal walls in their tendency to give one the impression that he had his finger on what appeared to be a structure, about the size and consistency of the appendix—most deceiving unless these are excluded.

The first thing we should observe when palpating the abdomen for the appendix is the necessity of locating the cecum; this segment of the bowel in the greater proportion of cases is readily palpable and usually lies above the brim of the pelvis. We pass our hand downward until the end of the cecum slips upward under the fingers, this almost always

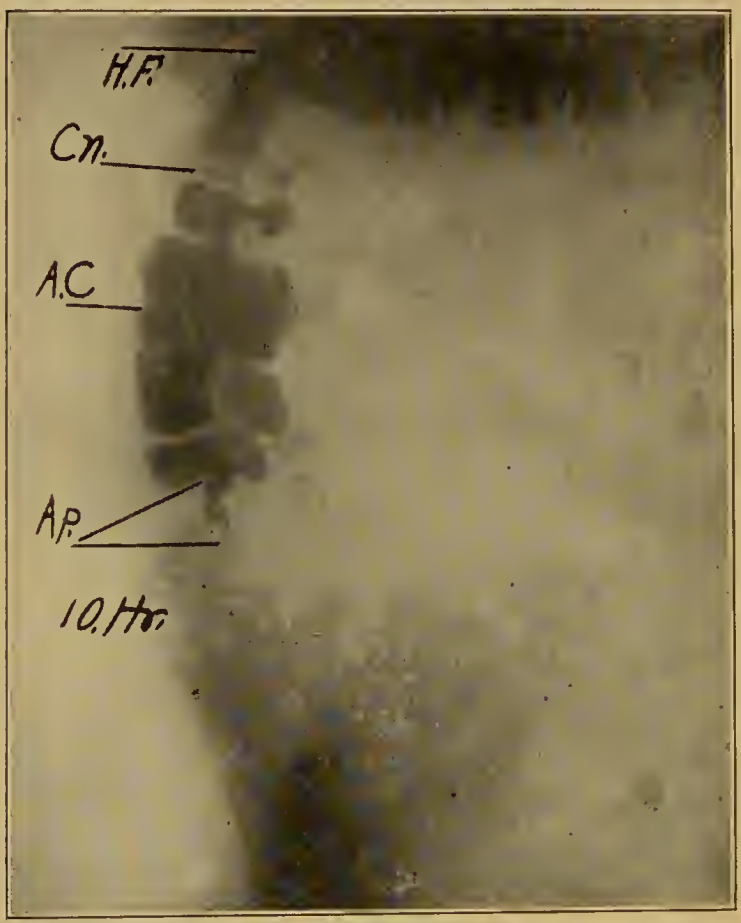
presents us with an outline of that portion of the cecum to which the appendix is attached. Placing a finger over the sulcus which is produced by the longitudinal band of muscles we may palpate the



RADIOGRAPH 14.—Miss F. Referred by Dr. Austin Cossitt. *Ap.* Appendix; *C.* cecum; *A.C.* ascending colon; *Sg.* sigmoid; *R.* rectum. This appendix is functionating, freely movable, can be readily displaced from one position to another and changed from the straight to the curved type. (Photograph has been reversed.)

base of the appendix. Once located at least seventy per cent. of appendices can be palpated; then if the opaque material has entered this structure we can readily see what we are hoping to find. The

determination of its condition, size, and shape follows. A large number of subjects have a mobile cecum which, if not adherent up in the abdomen, drops into the true pelvis when they are erect and, even if not adherent within the pelvis, is very diffi-



RADIOGRAPH 15.—Mr. K. Referred by Dr. J. Wallace Beveridge. *Ap.* Appendix; *A.C.* ascending colon. This appendix is nonfunctionating, kinked, movable, and descending. Although adherent to the cecum the mobility of the cecum permits it to be classed among the movable appendices.

cult to retract upward when the patient is placed in the Trendelenburg position. Frequently a cecum which rests in the pelvis is distended with feces

and literally wedged within this cavity and all efforts to remove it are in vain, but digital pressure from below may aid us in dislodging it. Occasionally a cecum so placed may be forced upward by the administration of a small enema, the rectum becoming distended it forces the colon upward.

The movable appendix may be readily displaced over a great area; this is proportionate to the length and condition of the mesentery of the appendix, together with the mobility of the cecum. The mobility of an appendix has a certain bearing on our interpretation of its condition but does not necessarily prove that it is not pathological, although, if mobile and functionating it can then be considered normal.

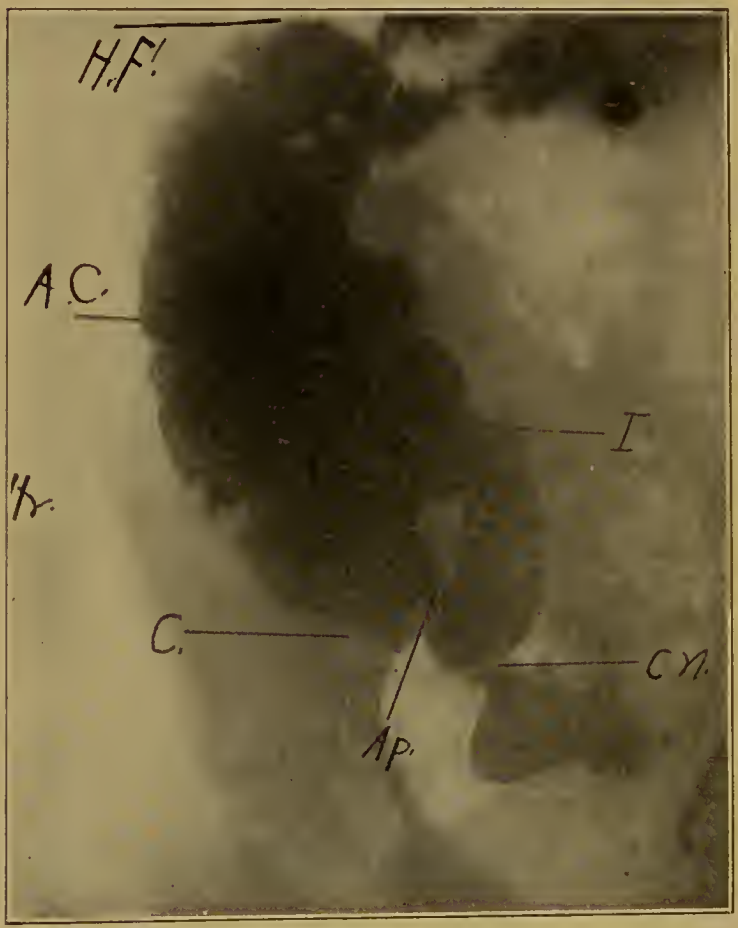
If the appendix is of the chronic type the muscular coat having been destroyed by inflammatory processes leaving the remaining tissue a flexible and hollow tube not able to properly discharge its entire contents, a residue of the feces containing the opaque salt may remain even after position or other conditions have partially drained the canal.

As the entire canal of the appendix is not of uniform calibre we do not expect to find on the screen or radiograph a symmetrical shadow outlining it in its due proportions. The bismuth salt may be retained in any segment of the canal. Very small particles may be distributed throughout its entire length mixed with feces which have entered the appendix previous to the administration of the bismuth; this results in small segmented shadows, the general distribution of which correspond to the location of the appendix. As observed in an accompanying radiograph it may be somewhat evenly distributed in segments which suggest a string of sausages. (See Dr. J. T. Case.)

The adherent appendix is not always fixed in its position while it may be adherent to the cecum, ileum, or its mesenteries; at the same time it can be freely moved about with these structures. On the other hand a fixed appendix is adherent to the ab-

dominal wall or bound down by numerous adhesions involving all the surrounding intestines.

The soft tissues which compose the wall of the appendix, with a few exceptions, do not cast a shadow. The writer has had two cases in which



RADIOGRAPH 16.—Mr. F. Referred by Dr. J. Wallace Beveridge. *Ap.* Appendix; *C.* cecum; *I.* ileum; *Cn.* constriction of the ileum where the tip of the appendix is adherent to it. In this case there is a marked iliac constriction which can be readily palpated. The appendix was palpable, of the nonfunctionating, movable, descending, and looped type.

the wall of the appendix was of sufficient density to cast a shadow which could readily be seen. The

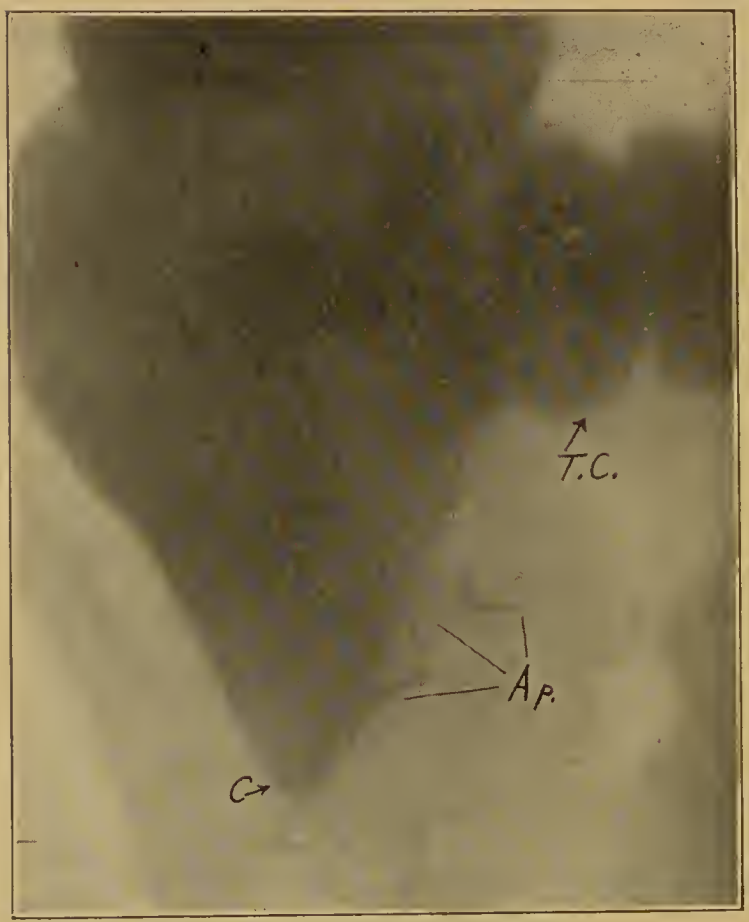
difficulty of reproducing the shadow of the soft tissues in half tones prohibits demonstrating them in published radiographs. In the original radiograph it will be observed that there is a very thin line, pointing downward from the cecum, which is the opaque material. When the soft tissues can be

RADIOGRAPH 17.—Mrs. C. Referred by Dr. Joseph McCarthy. *Ap.* Appendix; *I.* ileum; *C.* cecum; *H.F.* hepatic flexure; *U.* Umbilicus. Appendix is nonfunctionating, movable, transverse, and looped, adherent to the ileum. The canal of this appendix is very slender rendering it difficult to outline in half tone the entire length, which can be seen on the original radiograph.

seen in the radiograph they should be regarded as a deposit of scar tissue which has replaced the nor-

mal appendix and is evidently due to a chronic inflammation.

A number of patients with chronic appendicitis reacted very quickly to manipulation of the right side, and the abdominal wall at once became very



RADIOGRAPH 18.—Mr. H. Referred by Dr. Harold Meeker. *Ap.* Appendix; *C.* cecum; *T.C.* transverse colon. This appendix is very much distorted. It is adherent to the cecum and ileum. It is movable, nonfunctionating, and kinked. Although tightly bound to these structures it could be readily displaced about one inch when the cecum was manipulated.

rigid. Usually fat individuals or those with a persistently rigid abdomen are very hard to examine

and, while with the fluoroscope we may see what we believe to be the appendix yet we are unable to palpate the organ.

My routine practice consists in the examination of the entire alimentary canal and extends over a period of from four to six days. As a rule the appendix is found to contain bismuth on the second day or at the end of the thirty hour period. There are so many exceptions to this that we should not make it a practice to depend on the time factor. My practice is to expect the appendix to be filled with bismuth any time after six hours.

FILLED BY MASSAGE.

This routine examination elicits all the anomalies which occur and enables the examiner to report very definite findings especially if sufficient time is taken with each case. The total time spent by the examiner with each patient is approximately five hours. The subject is examined from seven to twelve times. This may appear to be excessive, but a correct finding can only be made by close attention to detail and inspection of each segment of the alimentary canal as the opaque salt passes from mouth to anus. At times one is tempted, and occasionally will be superficial in the inspection of a case that does not justify so much time and labor, but the valuable data obtained will reward the examiner and are a stimulus to do careful work.

The vast risk assumed by the examiner in the numerous fluoroscopic inspections that are demanded in following the bismuth meal, and especially in examining the right lower quadrant to determine the condition of the appendix and the presence of iliac kink, must always be considered.

One may determine the location of an appendix and state that it contains bismuth the usual length of time, and so conclude that it is the chronic type and, being satisfied with this, may fail to prove the presence of adhesions or other abnormalities.

The exceptional number of appendices observed

in the cases examined leads the writer to believe it is very rare for an appendix to become obliterated to such an extent, as to prevent material from entering its canal. Some may take exception to this statement, but as long as an appendix contains a mucosa which secretes, drainage must be provided therefore although the canal may be very small, it exists, and is capable of receiving foreign material. Again, I have observed some appendices receive the bowel contents in but a portion of their entire length and with palpation have then demonstrated the entire canal structure. In these cases, when operated and the appendix compared with the radiograph, it will be found to be considerably longer than its shadow.

CONCLUSIONS.

1. When there is chronic constipation due to delayed or inhibited peristalsis the appendix is usually diseased.

2. In the differential diagnosis of the appendix the x ray is essential.

3. When the pathological condition of an appendix is suspected and there are few symptoms an x ray finding is essential.

4. When the appendix is tied up in a mass of adhesions an accurate finding of the appendix enables the operator to rapidly locate it at operation.

5. Accurate determination of conditions typifying appendicitis should be made before operation.

6. When there are obscure symptoms in the abdomen which cannot be traced to a definite organ an x ray examination of the appendix may show that it is adherent to some distant organ.

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